ing the length of the wings W in Fig. 2. The proper length is found experimentally close to the transmitter. It is practically impossible to do so far away.

It has been said that Mr. Marconi has done nothing new. He has not discovered any new rays; his transmitter is comparatively old; his receiver is based on Branly's coherer. Columbus did not invent the egg, but he showed how to make it stand on its end, and Marconi has produced from known means a new electric eye more delicate than any known electrical instrument, and a new system of telegraphy that will reach places hitherto inaccessible. There are a great many practical points connected with this system that require to be threshed out in a practical manner before it can be placed on the market, but enough has been done to prove its value, and to show that for shipping and lighthouse purposes it will be a great and valuable acquisition.

CHARACTERS, CONGENITAL AND ACQUIRED.

The characters of a living organism, plant or animal, are usually grouped by biologists under two heads, the congenital, or inborn, and the acquired. But hitherto no systematic attempt has been made to give precision to these terms—to define precisely what we mean by them, and in the case of any particular organism to ascertain exactly which of its characters are inborn and which acquired. I know nothing in the whole range of science which promises to the thinker more immediate and solid results than this strangely neglected field of investigation. For example, had it received the attention it deserved, it is probable that the great controversy as to the transmissibility of acquired traits between the Neo-Lamarckian and Darwinian schools would long ago have ceased, since only after it has been definitely determined whether this or that trait is inborn or acquired can the fact of its transmissibility or non-transmissibility profitably be used as an argument for or against the Lamarckian doctrine. This precisely the disputants have not done—an assertion I shall justify presently. To deal with my subject adequately one should have the powers of a Darwin or a Herbert Spencer; if, however, I can contrive to direct attention to it I shall be well content.

An inborn variation may be defined as one which arises in an organism owing to changes previously produced by the action of the environment in the germ cell (or pair of germ cells) whence it sprang. As inborn variations are admittedly transmissible, all inborn characters must have arisen thus in the ancestry* and, deductively, it must follow, as, indeed, may easily be proved inductively,† that changes in a germ cell tend to be reproduced in its descendant germ cells, for which reason the organisms that arise from them tend also to reproduce the inborn variations of the parent organism.

An acquired character may be defined as one which arises in the organism owing to changes produced by the action of the environment, not on the germ cell, but on the somatic cells derived from it. If acquired modifications are transmissible, then changes in the somatic cells must tend so to modify the germ cells associated with them that, as a consequence, the organisms they proliferate into tend to reproduce, as inborn characters, the *particular* variations which were acquired by the parent organism.

* That is, if we accept the Neo-Darwinian doctrine.

† All unicellular organisms are germ cells; that is, they are all capable of continuing the species. When modified by the action of the environment they tend to transmit their modifications to descendant organisms, as has been abundantly proved by bacteriologists. A striking example is afforded by the organism which produces small-pox. If transferred to the cow it becomes so modified in the new environment that it ever afterwards causes in man, not small-pox, but cow-pox.

I dare say that the above definitions will be objected to by some of my readers, but I am in hopes that, on consideration of what follows, the majority will assent to them as indicating pretty correctly what we really mean by the terms 'inborn' and 'acquired.' I do not here propose to discuss the question as to whether acquired modifications are transmissible; I have done it at length elsewhere, and my present object is rather to differentiate accurately between the acquired and the congenital, and to ascertain the parts played by them respectively in the organic world. I may, in passing, however, notice one or two points which have been frequent sources of confusion and the consideration of which may help to bring the meaning I intend my definitions to bear clearly before the mind.

It has often been maintained by Neo-Lamarckians that important modifications in the soma (*e. g.*, the effects of disease) *must* affect the associated germ cells, and that therefore acquired modifications *must*, to some extent, be transmissible.* They miss the point at issue. It is not denied that changes in the germ's environment (*i. e.*, in the body of the parent) may result in modifications in the organism into which the germ subsequently proliferates, but it is strenuously denied that acquired modifications in the parent tend specially so to modify the germ as to cause the organism into which it subsequently proliferates to reproduce congenitally the particular modification which the parent acquired. Again, supposing some cause (*e. g.*, disease) produced a modification (*e. g.*, cavities in the lungs) in the soma and that subsequently, in the absence of the cause, the offspring developed the modification; even this would not constitute an absolute proof of the Lamarckian doctrine, though it would raise a presumption in favor of it. For it must be remembered that it is not asserted that a force acting on an organism cannot produce such a change in the germ as will cause the organism into which it develops to exhibit a variation similar to the modification produced by the force in the parent, but that it is asserted that this coincidence, this mere coincidence, must, from the nature of the case, be extremely rare, so very rare that, as factors in evolution, such apparent, but only apparent, transmission of acquired traits may practically be ignored. Only after it had been shown that clear and indubitable cases of reproduction by the offspring of the parents' modification were not uncommon in nature could the truth of the Lamarckian doctrine be accepted as proven.

* "The germ is a unicellular organism and therefore it should be modifiable in accordance with its environment. Such environment would be different in the body of a sedentary clerk and a hard-working agricultural laborer, and on this hypothesis the offspring in these cases would be different." (S. S. Buckman, *Natural Science*, March, 1897, p. 189.)

Watching the multiplication of an infusorian (*Stylonychia Pustulata*), Maupas observed that, after two of these had conjugated, the resulting fertilized cell divided and redivided many times without conjugation again occurring, but that if, after a certain pretty definite number of cell-divisions, conjugation did not again occur, the race ultimately died out. He found, moreover, that the descendants of a conjugated pair did not conjugate among themselves, but only with the descendants of another conjugated pair. All this is the rule among higher plants and animals. The ovum and the sperm are unicellular organisms. After conjugation they divide and redivide many times without conjugation again occurring among the descendant cells. But these, like the infusorians, if they do not conjugate, ultimately die out. Most of them (*i. e.*, the somatic cells) are incapable of conjugation, while such of them as are capable of conjugation (*i. e.*, the germ cells) conjugate only with cells

from another body (*i. e.*, cell-family). There are, as is well known, exceptions to the above; unending reproduction may occur without conjugation, as among such plants as are propagated by slips or suckers, and self-fertilization also occurs, but the general rule is as I have stated. A multicellular plant or animal in the successive stages of its development is therefore the homologue, not of the remote ancestral unicellular organism, but of all those successive generations of unicellular organisms which intervene between one act of conjugation and the next.

Unlike the cell descendants of a conjugated unicellular organism, the cell-descendants of a conjugated germ differ from it, and from one another, in that they undergo differentiation along certain definite lines (into nerve, muscle, bone, etc.), the germ cells being so specialized that the cell-communities which spring from them are very like the cell-community of which they were cell-members, for which reason a man, for instance, is like his parent. Moreover, the cell-descendants of the conjugated germ differ from the cell-descendants of the conjugated unicellular organism in that they remain adherent, and in that, in different lines of descent, they multiply at different though definite rates. Did the cell-descendants of the germ all multiply at an equal rate, a solid spherical mass of cells would, of course, result; whereas, owing to differences in their rates of multiplication, the shape of multicellular plants and animals are irregular (*i. e.*, not spherical). But, though these rates of multiplication in different lines of descent are pretty definite in every species of plant and animal, they differ widely in different species, whence arise differences in shape betwixt one species and another. An ox, for instance, differs in shape from a man because in it the cells in different lines of descent do not multiply at the same rate as in the man.

We cannot doubt that, when first multicellular organisms were evolved from unicellular, all the cells constituting the mass were morphologically and physiologically similar, and that, therefore, like the ancestral unicellular organism, every cell was capable of performing all the functions of life—food-getting, locomotion, reproduction of the race, etc. Later, as a result of natural selection, differentiation appeared among the adherent cells of the community, some taking on one function and some another, till at length a high degree of differentiation resulted, and the reproduction of the race was delegated to the germ cells.

As I have already indicated, among the unicellular organisms every cell is a germ cell, and as such is capable of continuing the race. Among low multicellular organisms this power persists in many cells, and the environment decides whether it shall be exercised or not; thus, if almost any fragment of a sponge be bedded out it will proliferate into a complete individual. It persists longer in plants than in animals; thus from a fragment of begonia leaf may arise an entire individual capable of continuing the race; the cells are being turned from their original destiny by a change in the environment. But among the higher plants this power of reproducing the entire individual by means of cells other than germ cells, or what may normally proliferate into germ cells, is very exceptional. All that commonly persists is the power of reproducing from such fragments of the complete organism as contain cells, which might normally proliferate into germ cells, the parts wanting to render the fragment a complete organism. Thus a geranium slip (for instance) contains cells which normally (*i. e.*, when the branch remains part of the plant) proliferate into germ cells; if this branch be bedded out as a slip it produces the roots which are needed to convert it into a complete organism of its

species. Here germ cells are not produced from cells not destined to that purpose as in the begonia leaf, but lost parts are reproduced by what may be termed (and in fact is) an exaggerated process of healing. In other plants the power of reproducing lost parts is present in a much smaller scale, and only comparatively trifling injuries are healed; *i. e.*, a small fragment cannot reproduce the whole, though the whole can reproduce lost fragments. Among animals, owing to the greater specialization of the cells and the more complex condition under which they live, this power of reproducing lost parts is present in general to a much less extent than among plants. Low in the scale, as we see, a fragment of sponge, for instance, can reproduce the whole. Higher in the scale, a starfish can reproduce a ray, a lobster a claw, a lizard its tail, and so forth, but none of these parts can reproduce the whole; that is done solely by germ cells. Higher yet, as among birds and mammals, the power of reproducing lost parts is comparatively very trifling; important and complex parts cannot be restored. Wounds and mutilations are healed, but, if serious, very imperfectly, for only scar tissue replaces the normal tissues which were lost.

We see, then, that the reproduction of lost parts, whether it be on a very great and perfect scale, as when a fragment reproduces a whole as in a sponge, or whether it be on a very small and imperfect scale, as when a wound is healed in one of the higher animals, is a process of the same order. Now, we speak of a scar in man, for example, as an acquired character; but who would dream of speaking of all that which is reproduced by the fragment of a sponge or a begonia leaf as a character acquired by the fragment. Moreover, when one of the higher animals is mutilated, as when a dog loses his tail, we lump together both the mutilation and the tissue with which the lost part is replaced (*i. e.*, the scar) as a single acquired character. But, even if we should agree for convenience to regard the scar as an acquired character, surely the mutilation ought not to be so designated, but should rather be termed (as I venture to suggest) *an enforced* character. We see, moreover, that the power of reproducing lost parts to a greater or less extent persists throughout organic nature, but that this power is vastly greater low in the scale than higher. In other words, if we agree to regard such reproductions as acquired, observation proves that the power of acquiring them is very much greater low in the scale (*e. g.*, sponge) than it is higher (*e. g.*, man).

On the other hand, there is another class of acquired characters—*perhaps the only class to which the term should properly be applied*—the power of acquiring which is greatest among the highest animals, and apparently is little or not at all present among the lower animals, nor in the whole of the plant world. I speak of such characters as arise as a result of exercise and use, as, for instance, the increased muscular power of an athlete. In the plant world no characters can, of course, be acquired as a response to the stimulation of exercise and use. Plants, therefore, of necessity, attain their full development in the absence of all other stimulation than such as is supplied by sufficient food and warmth. Of such plant-like animals as sponges the same also, of necessity, is true. It is true, with possible exceptions, even of such active animals as insects. Thus a pupa may develop into a perfect insect while lying quiescent. The lower vertebrates, such as fish and reptiles, have also little or no power of developing in response to the stimulation of use and exercise; apparently they are able to grow into normal, adult animals in its absence; thus if a tadpole finds its way through a crevice into a small cavity, and is able to obtain sufficient food, it develops

into a normal frog, though it leads a purely vegetative life. Higher yet in the scale among birds and mammals, and most of all among the highest mammals, the animal attains its full development, as regards many structures, only in response to the stimulation of exercise and use; thus, for instance, if the limb of an infant be locked by paralysis or by a joint disease so that it cannot be used it does not develop into an adult limb. Now, if a 'normal' man takes a more than ordinary amount of exercise he gets a more than ordinary development of various structures, as happens in the case of the blacksmith's arm. This extra development is regarded by biologists as 'abnormal' and is rightly termed 'acquired.' But, as we see, the 'normal' degree of development is attained only as a response to exercise (*i. e.*, stimulation), similar in kind though less in amount. *Therefore, it is clear that the full development of the normal adult arm, as well as many other important structures, is acquired*, differing in this from eyes, ears, teeth, nails, etc., which are wholly inborn, and do not owe their development in the least to use and exercise. In fact, on consideration, I think it will be found that adult man differs physically from the infant almost wholly in characters which are acquired, not in those which are inborn. In teeth, hair, skull-bones, genital organs, and in some other respects, he differs from the infant as regards inborn characters; but as regards almost all the structures of the trunk and limbs, and most of those of the head, the difference is in characters which have been acquired by the adult as a response to the stimulation of exercise and use. Thus the limbs develop wholly in response to use, the heart and arteries develop within certain limits in proportion to the strain put on them, as also do the lungs and their accessory muscles, as well as the bony attachments of the latter. The muscles, arteries, nerves, etc., of the head and neck also develop in response to the same stimulation. Moreover, the normal standard of development is maintained only as a response to this stimulation (*i. e.*, use, exercise), for example, when not used, the muscles with their coördinated structures atrophy and tend to disappear, as in the case of a paralyzed limb. It may be added that it is probable that even the infantile standard of development is, to some extent, acquired under the stimulus of fœtal movements in utero.

In upholding the doctrine of the transmissibility of acquired modifications much stress has been laid by Mr. Herbert Spencer and others on the exquisite coördination of the multitudinous parts of the high animal organism. They maintain that this coördination affords decisive proof of the Lamarckian theory, the line of argument being as follows: It is not probable that all the many structures of a high animal can ever have varied favorably together (as compared to the parent) in any individual animal. It is unbelievable that they can all have varied favorably generation after generation in a line of individuals. A chain is only as strong as its weakest link. A favorable variation, say a larger horn in the elk, if unaccompanied by corresponding variation in all the thousand parts (in head, neck, trunk, limbs) coördinated with it, would be useless, and even burdensome. In other words, if a single structure (muscle, bone, ligament, etc.) of all those associated with it failed to bear the strain of the larger horn, this variation would not favor survival, but, on the contrary, be a cause of elimination. Therefore, say these thinkers, the evolution of high multicellular animals cannot be attributed to the accumulation, during generations, of inborn variations alone, but must in part be attributed to the accumulation, during generations, of the effects of use and disuse, *i. e.*,

to the accumulation of acquired variations.

But variations acquired as a result of use and disuse are plainly never transmitted. Thus an infant's limb never attains to the adult standard except in response to the same stimulation (exercise) as that which developed the parent's limb. The same is true of all the other structures which in the parent underwent development as a result of use, or subsequent retrogression in the absence of it. These, like the limbs, do not develop or retrogress in the infant except as a result of similar causes. Plainly, then, what is transmitted to the infant is not the modification, but only *the power of acquiring it under similar circumstances*—a power which has undergone such an evolution in high animal organisms that, as I say, in man, for instance, almost all the development changes which occur between infancy and manhood are attributable to it. It follows, therefore, that the exquisite coördination of all the parts of a high animal is not due to the inherited effects of use and disuse, but to this great power of acquiring modifications along certain definite lines; so that if an animal varies in such a way as to have one of its structures (*e. g.*, horn, a structure which is wholly inborn) larger than in the parent, then all the other structures associated with it, owing to the increased strain (*i. e.*, the increased stimulation) put on them, undergo a corresponding modification, and thus preserve the harmony of all the parts of the whole. So also if the horn (for instance) be smaller than in the parent, the lesser strain placed by it on associated structures causes these also to develop less than in the parent, whereby again the harmony of the whole is preserved.

I have dwelt at greater length on this neglected subject of acquired characters (properly so-called) elsewhere,* but I think I have said enough even here to demonstrate its immense importance. The power of acquiring fit modifications in response to appropriate stimulation is that which especially differentiates high animal organisms from low animal organisms.* Without this power and the plasticity which results from it the multitudinous parts of high animals could not well be coordinated, and, therefore, without it their evolution could scarcely have been possible. Indeed, it is not too much to say, so vitally important is this power to the higher animals, that, as regards them, the chief aim (if I may use the expression) of natural selection has been to evolve it. But, since this power of developing in response to the stimulation of use operates mainly along certain definite lines, which are not quite the same in every species, the different species differ as regards size and shape, not only in characters which are inborn, but also in those which are acquired. Thus an ox differs in size and shape from a man not alone in inborn characters, but also in characters which are acquired as a result of exercise and use. The structures of both the ox and man develop in response to appropriate stimulation, but not quite in the same direction, nor in the same proportion, nor to the same degree; hence, to some extent the differences in size and shape betwixt the two animals. Consider, for instance, the hind limbs of the ox and man: in both these grow greatly as a response to the stimulation of exercise, but the lines of growth being somewhat different the limbs do not approximate in shape and size. Presently, when we consider mind, we shall realize even more strikingly the importance of our subject, and perceive how deeply it concerns many fields of thought and investigation which have greatly interested mankind in all ages; but I have still something more to say as regards

* Vide *The Present Evolution of Man*, pp. 108–21.

* The truth of this, as we shall see, is made particularly manifest by the study of mind.

physical characters, though it is not possible in the space allotted me to do full justice to the theme.

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*THE DESIRABILITY AND THE FEASIBILITY OF THE ACQUISITION OF SOME REAL AND ACCURATE KNOWLEDGE OF THE BRAIN BY PRE-COLLEGIATE SCHOLARS.**

NEVER before has the need of information as to the structure and function of the nervous system been so keenly felt by experts in various branches of knowledge and by practitioners of various specialties.

Never before, likewise, has there been so general and so earnest a desire for such information among the laity. For the first time has it been claimed by a prominent educator that neurology is a prime constituent of a liberal education. Among the branches of knowledge essential to a liberally educated man President Gilman names (*Educational Review*, III., 105–119, February, 1892), "first, the knowledge of his own physical nature, especially of his thinking apparatus, of the brain and the nervous system, by which his intellectual life is carried forward."

Under prevailing conditions, however, any approximation to a real and accurate knowledge of the brain is gained by but few, and at a late educational stage. Hence the public are ignorant or misinformed,* and the time that specialists might devote to research and advanced instruction is consumed in acquiring and im-

* This article is based upon a paper presented at the meeting of the American Society of Naturalists in Boston, December 29, 1896; it is an extension of the views expressed by that Society in 1891, 1892 and 1893 regarding a science requirement for admission to college and the introduction of natural history studies into the lowest grades of schools. It also embodies the substance of published or unpublished remarks upon the subject made by the writer on the following occasions:

1889.—In the article 'Anatomical Terminology,' Reference Handbook of the Medical Sciences (VIII., p. 532, § 82), occurs the following passage: "Aside from prejudice and lack of practical direction as to removing, preserving and examining the organ, there is but one valid reason why every child of ten years should not have an accurate and somewhat extended personal acquaintance with the gross anatomy of the mammalian brain; that obstacle is the enormous and unmanageable accumulation of objectionable names under which the parts are literally buried."

The foregoing paragraph is reproduced in a footnote upon p. 335 of my paper, 'Neural Terms, International and National,' *Jour. Comp. Neurology*, VI., 216–352, December, 1896 (issued February, 1897).

1896, a.—An address before the Home Congress, in Boston, October 13, 1896, was entitled 'Brains for the young: the desirability and the feasibility of the acquisition of some real knowledge of the brain by precollegiate scholars.' Through misapprehension a report of the address was printed in the *Arena* for March, 1897, pp. 575–583. Although unauthorized and containing some errors, it fairly represents what was said.

1896, b.—At the meeting of the New York State Science Teachers' Association in Buffalo, December 31, 1896, in the discussion on Biology in the Schools, the main points of the article above named were briefly stated; they were correctly reported in SCIENCE, April 2, 1897, p. 537.

1897.—A paper on 'The practical study of the brain in a primary school' was read before the University Convocation, June 29, 1897.

*Among the anxious parents and teachers to whom they are addressed how many are able to profit by the information contained in, for example, Donaldson's 'The growth of the brain' and Halleck's 'The education of the central nervous system?' How many persons recognize as erroneous the statements so frequently made as to the supreme absolute or relative size of the human brain? May not high school pupils describe the rivers of Africa and even the 'canals' of Mars and yet be so little familiar with the topography of the cerebrum as to accept without question the alleged representations thereof in most text-books, misrepresentations that might serve equally well for a heap of sausages? A large part of the community is at the mercy of charlatans, and squanders time and money upon that peculiarly American humbug, phrenology as practised. In a recent issue of a popular magazine, whose editor is sincerely interested in education, is an article containing not merely the phrenologic misstatements and vapidities, but a diagram of the 'convolutions of the brain' which has no basis of fact.